



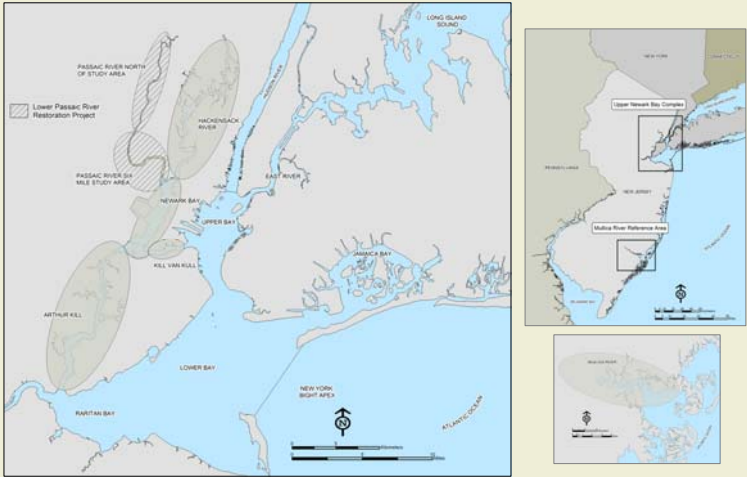
ASSESSING TCDD-TEQ RISK IN A NEW JERSEY URBAN INDUSTRIALIZED WATERWAY



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STUDY AREA



New York/New Jersey Harbor Area. Newark Bay Complex includes the tidal Passaic (17 miles between Dundee Dam and its confluence with Newark Bay, Hackensack River between Oradell Dam and its confluence with Newark Bay, Arthur Kill, Kill van Kull and their tributaries.

SITE INFORMATION

The Newark Bay Complex, an important economic, ecological and cultural resource, consists of 89 linear km (55 mi) of waterways, 389 km (242 mi) of shorelines, and encompasses 44 km² (17 mi²) of water.¹ Over 75 aquatic species utilize the area for feeding, breeding, and nursery habitat. Numerous bird species, including colonial wading birds, also use this area for feeding, breeding, and migratory stopovers. Portions of the complex have been designated significant habitat by the U.S. Fish and Wildlife Service.² While the public uses this area for recreational purposes, fish consumption advisories have been in effect since the mid-1980's due to the presence of dioxin and PCBs.³ In addition to providing significant habitat for fisheries, this area supports major shipping and maritime activities.

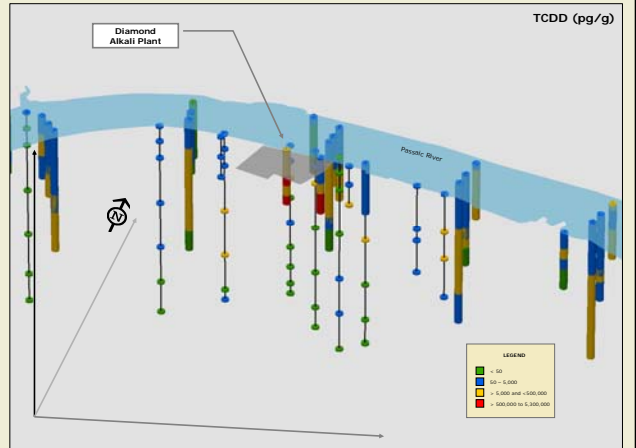
Situated on the southern shore of the tidal Passaic River in the highly industrialized city of Newark, New Jersey, the Diamond Alkali Plant produced DDT and phenoxy herbicides beginning in the 1940's, as well as various other chemicals throughout its industrial history.⁴ This herbicide manufacturing history included the production of > 3.1 million liters (>820,000 gal) of Agent Orange during the Vietnam War.⁵ Dioxin is a by-product of the phenoxy herbicides. An estimated 4 to 8 kg (~ 9-18 lbs) of 2,3,7,8- tetrachlorodibenzo-*p*-dioxin (TCDD) was deposited into Newark Bay from this facility over a 40 year period, rendering the Diamond Alkali Plant as the primary source of dioxin contamination to the Newark Bay Complex (NBC).⁶ TCDD, in a sediment core from a mudflat adjacent to the Diamond Alkali Plant was measured at 5,200 pg/g in the top 15.24 cm (6 inches) with a maximum of 5,300,000 pg/g at 1.4-1.7 m (4.5-5.5 ft) depth. Octachloro-dibenzo-*p*-dioxin (OCDD), in the same core reached 8,340 pg/g in the top slice and 802,000 pg/g in the subsurface.⁷ Numerous other organic and inorganic contaminants, in addition to polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) were detected above screening criteria,⁸ but are not the focus of this analysis.

[1] Calculated using ArcView 8.3 GIS. [2] USFWS 1997. [3] Belton et al. 1995, NIDEP 2003. [4] USEPA 1987. [5] Maxus Energy Corp v. USA 1992. [6] Bopp 1991. [7] NOAA 2003, Maxus 1995. [8] NOAA 2003

SUB-SURFACE SEDIMENT



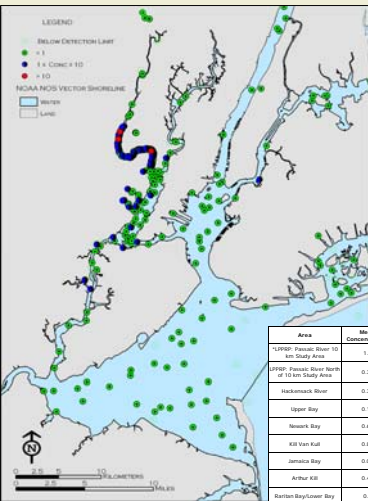
Maximum (for core) subsurface sediment TCDD concentrations for the years 1990-2000. Shows maximum concentrations adjacent to Diamond Alkali Plant.



Subsurface sediment profile shows distribution of TCDD in cores adjacent to the Diamond Alkali Plant including pre-release conditions below maximum concentrations.

SURFACE SEDIMENT

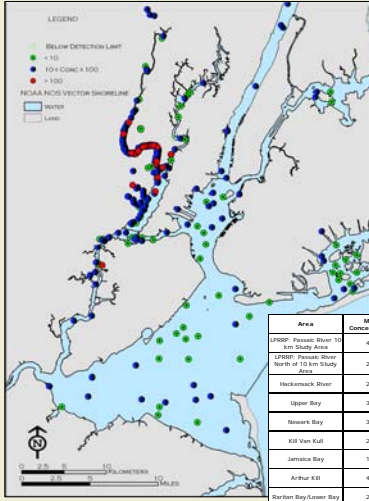
Total PCB's (ug/g)



Surface sediment total PCB concentrations for the years 1990-2000. Highest concentrations are documented in the Passaic River. Concentrations tend to decrease as one moves further away from the Passaic River.

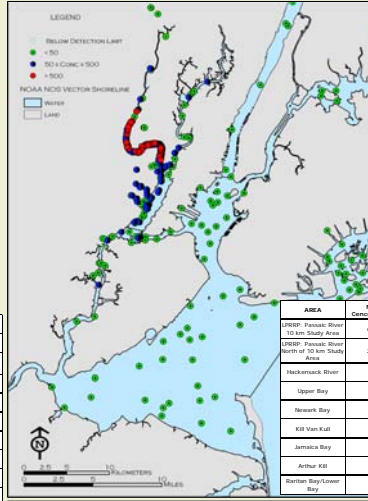
*LPRRP = Lower Passaic River Restoration Project

TCDF (pg/g)



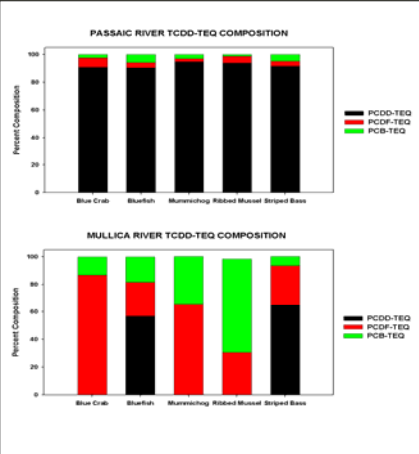
Surface sediment TCDF concentrations for the years 1990-2000. The spatial distribution pattern for TCDF was much less distinctive than observed with TCDD. Mean and concentration ranges were similar for the lower 10 km of the Passaic River and the Arthur Kill and there was less than 3 fold difference between all locations. Mullica River average TCDF was most similar to Jamaica Bay.

TCDD (pg/g)

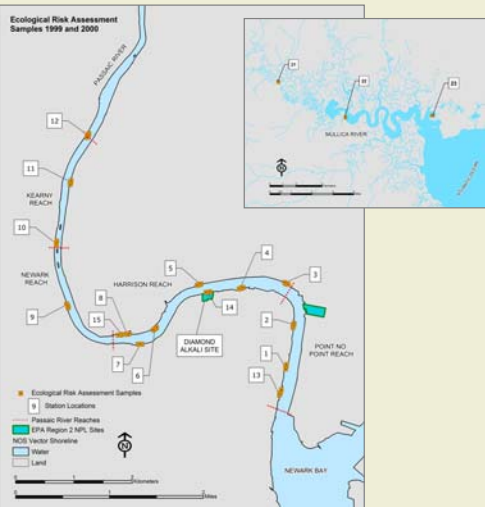


Surface sediment TCDD concentrations for the years 1990-2000. Highest mean and maximum concentrations were detected in the lower Passaic River. Concentrations tend to decrease with increasing distance from the Diamond Alkali Plant. Mean surface sediment TCDD are about an order of magnitude higher in the Passaic River than Newark Bay, Hackensack River, or Arthur Kill and decrease another order of magnitude in the Upper Bay, Lower Bay and Raritan Bay. Maximum concentrations in the Passaic River are 1-3 orders of magnitude higher than elsewhere. Mullica River average TCDD was the same as Jamaica Bay, but with a smaller variance.

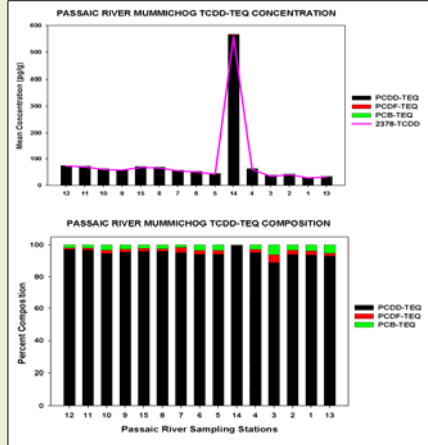
PCDD, PCDF, AND PCB CONTRIBUTIONS TO TCDD-TEQ



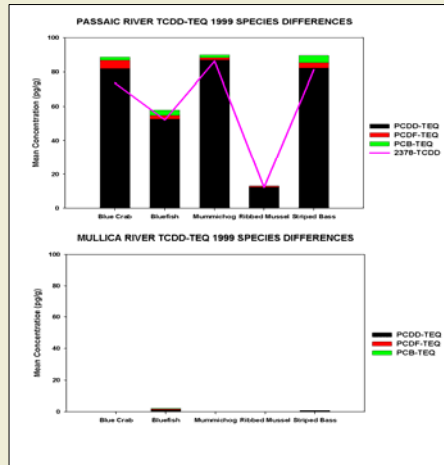
PCDD-TEQ contribute >90% to the total TCDD-TEQ in the Passaic River regardless of species analyzed. TCDD comprised 99% of the PCDD-TEQ and between 90% and 96% of the TCDD-TEQ for all species evaluated. These trends did not hold for the same species collected from the Mullica River. PCDDs, including TCDD, were not detected in ribbed mussels, blue crab and mummichog. PCDD-TEQ contribution to TCDD-TEQ was >50% but <70% for bluefish and striped bass.



Ecological sampling stations along the 10 km study area of the lower Passaic River. Diamond Alkali = Station 14.



Passaic River mummichog TCDD-TEQs are dominated by PCDD-TEQ with TCDD as the main contributor to PCDD-TEQ. Greater than 99% of the TCDD-TEQ at station 14 was attributable to PCDD-TEQ. PCDF and PCBs contribution to overall TEQ was elevated at all the other stations relative to Station 14.



TCDD-TEQ, on a concentration basis, was orders of magnitude higher across the Five species of biota and invertebrates examined in the Passaic River compared to the Mullica River. TCDD in Passaic River blue crab hepatopancreas (not shown) was three times higher than that of soft tissue (shown).

METHODS

NOAA developed a Newark Bay Watershed Database and Mapping Project by compiling sediment chemistry, tissue residue and bioassay results (<http://response.restoration.noaa.gov/cpr/watershed/watershedtools.html>) for a variety of contaminants and species. This database consists of numerous studies conducted between 1985 and 2001 by academics, state and federal agencies and private companies. As a consequence, various sampling and analytical methods were employed with different approaches to sediment segmentation schemes, tissues and organisms sampled, and chemicals analyzed.

Our original intent was to conduct an analysis of a subset of these data to determine the spatial distribution of PCDD, PCDF and PCBs in sediment and tissue throughout the NY/NJ Harbor area, to evaluate the contribution of each to tissue TCDD toxic equivalency (TEQs), and to assess risk to aquatic and piscivorous biota. Data constraints limited our ability to conduct as broad a geospatial analysis as planned. We ultimately analyzed sediment contamination harbor-wide, but narrowed our focus to the Passaic and Mullica Rivers for relative contribution, concentration, and risk analyses of TCDD-TEQ to aquatic and piscivorous biota.

2,3,7,8-TCDD and 2,3,7,8-tetrachlorodibenzo-*p*-furan (TCDF) concentrations in surface (general range of 2 to 15.24 cm) and subsurface sediments were determined throughout NY/NJ Harbor to explore mean and range of concentrations as well as spatial distribution.

To assess risk from organochlorines to aquatic biota, TCDD-TEQs were calculated by multiplying individual congeners of PCDD, PCDF and PCB by their respective fish Toxic Equivalency Factors (TEFs) and summing the TEQs.⁹ Diamond Alkali remedial investigation ecological sampling data collected between 1995 and 2001 over a 10 km (6 mi) stretch of the Passaic River were used to examine the degree of PCDD, PCDF, and PCB contamination in numerous aquatic species and the relative contribution of each to the total TEQ.

The 1999 dataset consisted of 15 Passaic River stations and three reference stations in the Mullica River. Station 14, adjacent to the Diamond Alkali Plant, is located about 3.2 km (2 mi) upstream from the downstream edge of the 10 km study area. Whole body tissue analysis was conducted for the three fish species while soft tissue was analyzed for the invertebrate species. Crab and mussel data were reported as one value per station, representing composites of 3 cages. Mummichog data reported as one value per cage with 3 cages per station.¹⁰

Ten species of aquatic biota collected from the Passaic River (1995, 1999-2001) and Mullica River (1999-2000) were used to generate TCDD-TEQs (as described above) for the risk analyses. Tissue residues were compared to species-specific toxic reference values (TRVs).¹¹ TRVs reported as dry weight liver concentrations were converted to wet weight by dividing by 3.¹² To estimate risk to piscivorous wildlife, TCDD-TEQs were also calculated on aquatic tissue data using avian and mammalian TEFs. These tissue residues were compared to Canadian guidelines developed for the protection of birds and mammals that consume aquatic prey.¹³

[9] Van den Berg 1998, [10] NOAA 2003, [11] Cook et al. 2003, Prince and Cooper 1995, Black et al. 1998, [12] Elkus personal communication 2003, [13] Canadian Council for the Environment 2001

CONCLUSIONS

- Concentrations of TCDD-TEQ were up to four orders of magnitude higher in the Passaic River biota compared to Mullica River biota.
- Mummichogs in the Passaic River show maximum contribution to TCDD-TEQ to be from PCDD adjacent to Diamond Alkali Plant.
- PCDD-TEQ dominated TCDD-TEQ in Passaic River biota with TCDD comprising 99% of the PCDD-TEQ and >90% of the TCDD-TEQ.
- In the Passaic River, the proportion of PCDD, PCDF and PCB to TCDD-TEQ was independent of species collected, size of home range or trophic status.
- Results for Mullica River PCDD, PCDF, PCB contribution to TCDD-TEQ present a different pattern reflecting a system with much lower concentrations of TCDD. Species home range and trophic status likely influence the observed patterns. We hypothesize that Jamaica Bay biota might exhibit similar patterns to Mullica River given similar surface sediment PCDD, PCDF, and PCB concentrations.
- TCDD-TEQ concentrations in Passaic River sediments pose a risk to fish, birds and mammals.
- Future studies should be designed in the Greater Newark Bay Complex to analyze sediments and biota for PCDD, PCDF and coplanar PCBs to evaluate concentration gradients, calculate TCDD-TEQs, and assess risk to ecological receptors.